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Statement of Work

for

Lunar Atmosphere & Dust Environment Explorer (LADEE) Project

Integrated S-Band STDN Transponder Component Assembly

Revision: A

Effective Date: April 19, 2010
Expiration Date: December 31, 2013

Ames Research Center (ARC)
Moffett Field, California

National Aeronautics and Space Administration

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Statement of Work for the Integrated S-Band STDN Transponder Component Assembly for the LADEE Observatory

DOCUMENT CHANGE RECORD

Sheet: 1 of 1

REV/ VER LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
-	Baseline Release of Document Per LADEE-CCR-0161	M. Allard S. Walker	3/18/10
A	Requirement Updates Coordinated with Performance Specification	M. Allard	4/19/10

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1.0 Introduction

1.1 General Information

The National Aeronautics and Space Administration (NASA), Ames Research Center (ARC) and Goddard Space Flight Center (ARC) have the stated mission to design, develop, integrate, launch, and operate the Lunar Atmosphere & Dust Environment Explorer (LADEE).

The Lunar Atmosphere & Dust Environment Explorer (LADEE) mission objective is to conduct investigations that will be specifically targeted to prepare for and support future exploration of the Moon.

Mission duration is estimated at 180 days maximum, depending upon fuel and orbit, however, all components are being defined for a minimum mission life of 1 year.

LADEE is a strategic lunar science mission with several objectives:

- Address the NRC Scientific Context for Exploration of the Moon goal of determining the global density, composition, and time variability of the fragile lunar atmosphere before it is further perturbed by future human activity,
- Demonstrate the ability to utilize optical laser communications equipment to provide high bandwidth communication from the Moon,
- Demonstrate a low-cost reusable spacecraft bus architecture for future Planetary Science missions, and
- Demonstrate the use of a small class expendable launch vehicle (e.g. Minotaur V for lunar missions from the Wallops Flight Facility.

This document defines the work to be performed for Contractor design, development, cost estimation, fabrication, qualification, and delivery of a low cost, low mass, low power, high performance, single string, Integrated S-Band STDN Transponder Component assembly with specific modifications necessary to provide the core active component assembly of the LADEE S-Band STDN communication subsystem supporting the LADEE mission as defined in the LADEE Integrated S-Band STDN Transponder Component Performance Specification; SPEC-003.LADEE.ITPSD.

The Integrated S-Band STDN Transponder Component shall be based on a high NASA Technology Readiness Level (TRL 8/9) S-Band STDN Transponder system core, comprised of a receiver/detector (Receiver) element, a Transmitter element, and related Power Distribution, Command, Control, Telemetry elements, for operation and information interfaces, supplemented by other RF components, such as an RF Transfer Switch element, an RF Bandpass Filter element, RF Coupler elements, an S-Band Diplexer element, an RF Splitter/Coupler element, and any interconnecting cabling and RF signal terminators, that are integrated into, on to, or around, the S-Band STDN Transponder system core, to form a single Integrated S-Band STDN Transponder Component assembly. This Statement of Work covers the three antenna version, as well as, an optional, two antenna, simplified, variant of

the design. Only one version of the design will be selected for procurement at award. The Integrated S-Band STDN Transponder Component assembly is intended to be mounted onto the spacecraft structure and connected into the spacecraft EPS and C&DH subsystems, to support up to two omnidirectional and one medium gain antennas to receive commands, encode and transmit telemetry, support provisioning of coherent / non-coherent ranging information, and provide tracking data, in a manner fully compatible with Earth-based Near Earth Network (NEN) and Deep Space Network (DSN) ground station resources.

Innovation and efficiency in materials selection and application, as well as, in design, engineering, meetings, and reviews, is invited to achieve a fully compliant deliverable with the greatest efficiency for technical performance, reliability, mass, power, and thermal load in the smallest dimension, surface area, volume, cost, and schedule.

1.2 General Requirements

The Contractor shall provide the facilities, personnel, services, tools, equipment, and materials necessary to design, modify, analyze, manufacture, inspect, test, and deliver:

- One (1) Flight Qualifiable Integrated S-Band STDN Transponder Component Engineering Unit
- One (1) Flight Qualified Integrated S-Band STDN Transponder Component Unit
- Hardware Accessories
- Ground Support Equipment
- Data and Documentation
- Technical Support

Both Integrated S-Band STDN Transponder Component Units are to be constructed utilizing parts and materials originating from the same batches and lot dates and use consistent construction and fabrication techniques in their assembly and adjustment.

1.3 Applicable Documents

All applicable and reference documentation identified in this document shall apply in the situations where they are specifically referenced. In the event of a conflict between the SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification (SPEC-003-LADEE.ITPSD), the SOW shall take precedence. See Appendix C for referenced documents.

2.0 Management, Reporting, Documentation and Reviews

2.1 Management and Reporting

The contractor shall designate a single individual who will be given full responsibility and authority to manage and administer all phases of the work specified by the contract, and ensure that all objectives are accomplished within schedule and cost constraints.

The contractor shall designate and identify by name a single individual who shall serve as a point of contact with the Ames Research Center (ARC) Contracting Officer Technical Representative (COTR) for all technical aspects of the LADEE Integrated S-Band STDN Transponder Component contract.

The contractor shall provide for managing all resources, controlling schedules, managing all engineering, manufacturing and procurement activities, configuration management, Quality Assurance, documentation control, and distribution.

The contractor shall prepare and present to the NASA/ARC COTR monthly status via a personal or an electronic collaboration meeting utilizing mutually agreed to collaborative meeting tools, such as teleconference, WebEx, or VideoTeleconference, and a written report. The report shall be a summary presentation of the period's progress, problem areas, schedule milestones, and activities on-going and planned. The contractor shall generate a list of significant milestones that will enable the NASA/ARC COTR to ascertain program progress.

In addition, every week, on an agreed day by the COTR and Contractor, the Contractor shall provide an informal report through email and, optionally, through collaborative meeting tools, on the current status of the LADEE S-Band STDN Transponder Component for that particular week. It should also comment on situations developed since the last report and developments planned for the following week. Additionally, it should also comment on potential problems the contractor might foresee that could affect the contract development, if any. Informal telephone calls and collaborative meetings might follow to clarify questions and discuss issues.

2.2 Documentation

The contractor shall ensure the generation and delivery of all documentation as called for in the Contract.

In addition to that documentation specifically called for in the Contract, upon request by the NASA/ARC COTR, the contractor shall make available a copy of any document or data generated during this contract performance for review by the ARC. This includes, but is not limited to, technical reports and memorandums, drawings, schematics, studies, analyses, parts and materials data, test data, alerts, etc.

2.3 Reviews and Meetings

The meetings required with the contractor are specified below.

Mutually agreed to use of collaborative multi-media remote collaboration tools, such as teleconference, WebEx, or VideoTeleconference are encouraged and shall be supported by the contractor as an augmentation to face-to-face meetings and site visits as may be required to improve collaborative technical interchange and reduce travel requirements.

The following reviews shall be performed-

2.3.1 Initial Technical Interchange Meeting (ITIM)

The Contractor shall plan for an informal, face-to-face, initial technical interchange meeting opportunity to be held as soon as possible after contract award at the contractor facilities, unless otherwise agreed to by the contractor and NASA/ARC COTR, per the contract schedule. The ITIM will be a specialized TIM (Refer to Section 2.3.7) that shall support initial baselining, review, and coordination of the project requirements and approach, including, but not limited to, clarification discussions on the LADEE spacecraft and mission details, details regarding the core transponder performance and contractor anticipated modifications required to meet all requirements, technical development approach, design analyses/coordination, as well as, further definition and finer trade-offs within the scope of the basic contracted design and specification requirements. The TIM meeting notice shall be seven (7) calendar days in advance of the meeting. The NASA/ARC COTR shall be responsible for ARC and GSFC review participants. Presentation materials shall be available for participants at the end of the Initial Technical Interchange Meeting.

2.3.2 System Requirements Review (SRR)

The Contractor shall organize and present a System Requirements Review (SRR) to an ARC Review Team at the Contractor's facility, unless otherwise agreed to by the contractor and NASA/ARC COTR, per the contract schedule. This review shall establish that the baseline requirements are clearly understood and that system definition is complete. This review shall also provide an opportunity to review drawings and all proposed analyses.

This review shall cover programmatic, technical, test and verification, and quality assurance topics. The SRR shall demonstrate that planning for the remaining project activities is adequate and that there are reasonable expectations that the project will accommodate any imposed constraints and meet its success criteria within the allocated resources.

The contractor shall provide to ARC a SRR Presentation Package and all other required deliverable data one week prior to the review. Refer to section 3.2.3 for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A System Requirements Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

2.3.3 Preliminary Design Review (PDR)

The contractor shall organize and conduct a Preliminary Design Review (PDR) at the contractor's facility, unless otherwise agreed to by the contractor and NASA/ARC COTR, before the start of fabrication and per the contract schedule. This review shall demonstrate overall conformance to the requirements specified in the LADEE Integrated S-Band STDN Transponder Component SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification for the preliminary design. This review shall provide a formal presentation of the architectural design of the LADEE Integrated S-Band STDN

Transponder Component. This review shall specify all the mechanical and electrical interfaces to the LADEE Integrated S-Band STDN Transponder Component. This review shall cover programmatic, technical, test and verification, quality assurance topics, and overall status. This review shall also provide an opportunity to review test plans and procedures and all analyses required to approve the fabrication of the hardware.

The contractor shall provide to ARC a Preliminary Design Review Presentation Package and all other required deliverable data two weeks prior to the review. Refer to section 3.2.4 for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Preliminary Design Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

2.3.4 Critical Design Review (CDR)

The contractor shall organize and conduct a Critical Design Review (CDR) at the contractor's facility, unless otherwise agreed to by the contractor and NASA/ARC COTR, before the start of fabrication and per the contract schedule. This review shall demonstrate overall conformance to the requirements specified in the LADEE Integrated S-Band STDN Transponder Component SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification; SPEC-003.LADEE.ITPSD. The review shall demonstrate overall conformance of the detailed design using completed drawings and analyses. Drawings and analyses should be released or ready for final review and approval. This review shall define all the thermal, mechanical, and electrical interfaces between the LADEE Integrated S-Band STDN Transponder Component and the LADEE spacecraft hardware and components. This review shall cover programmatic, technical, test and verification, quality assurance topics, and manufacturing and overall status. This review shall provide an opportunity to review drawings and test plans before the start of fabrication of the hardware.

The contractor shall provide to ARC a Critical Design Review Presentation Package and all other required deliverable data two weeks prior to the review. Refer to section 3.2.5 for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Critical Design Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

2.3.5 Pre-Environmental Review (PER)

The contractor shall organize and conduct a Pre-Environmental Review (PER) at the contractor's facility, unless otherwise agreed to by the contractor and NASA/ARC COTR, before the environment test program begins and per the contract schedule. This review shall

demonstrate overall conformance of the requirements specified in the LADEE Integrated S-Band STDN Transponder Component SOW for this phase of the procurement.

This review shall cover programmatic, technical, test and verification, and quality assurance topics. This review shall also provide an opportunity to review test plans and procedures and all analyses required to approve the testing of the hardware.

The contractor shall provide to ARC a PER Presentation Package and all other required deliverable data one week prior to the review. Refer to section 3.2.6 for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Pre-Environmental Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

2.3.6 Pre-Ship Review (PSR)

The Contractor shall hold a Pre-Ship Review at the contractor's facility, unless otherwise agreed to by the contractor and NASA/ARC COTR, after the completion of verification tests and prior to shipment of the hardware to ARC. A PSR shall be held prior to the delivery of each hardware item and per the contract schedule. The PSR shall include presentation of the as-built drawings and specifications and shall reflect all approved changes, and if there are differences between the hardware to be delivered and the drawings or specifications, those differences shall be listed and acceptance justifications presented. Performance and hardware differences from Flight Qualifiable Engineering Unit and the optional Flight unit shall be presented if necessary. At the time of the PSR, documents and analysis to support satisfaction of the requirements of the LADEE Integrated S-Band STDN Transponder Component SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification shall be complete, and all actions from previous reviews for the hardware delivery shall be closed.

The Pre-Ship Presentation Package shall demonstrate the completion of all applicable assembly and subsystem testing and that all applicable data has been captured and is ready for submission to the NASA/ARC COTR. A Data Delivery Package (reference 3.2.8) shall be presented for review at each PSR. A Differences List shall be provided for review at each PSR and shall be a part of the Data Delivery Package.

2.3.7 Technical Interchange Meetings (TIM)

The contractor shall plan for informal, face-to-face technical interchange meetings to be held at the contractor facilities, unless otherwise agreed to by the contractor and NASA/ARC COTR. These TIMs shall support review and coordination of technical issues including, but not limited to, parts, test plans, test procedures, software changes, design modifications, and design analyses. The TIM meeting notice shall be seven (7) calendar days in advance of each meeting. The NASA/ARC COTR shall be responsible for ARC and GSFC review

participants. Presentation materials shall be available for participants at the end of the Technical Interchange Meetings.

2.4 Notification to NASA/ARC Contracting Officer (CO) and Contracting Officer Technical Representative (COTR)

The contractor shall notify the NASA/ARC Contracting Officer and NASA/ARC Contracting Officer Technical Representative at least five (5) calendar days in advance of all mandatory hardware inspections, test activities, and deliveries at either the Contractor's or a sub-Contractor's facility to allow timely participation by the NASA/ARC Quality Assurance activities.

3.0 Engineering

3.1 General Requirements

The contractor shall perform analyses of the technical and environmental requirements specified in the LADEE Integrated S-Band STDN Transponder Component SOW to ensure compliance of the hardware fabrication and to assemble the documentation necessary to ensure its usability by NASA/ARC users.

3.2 Engineering Documentation

The system engineering analyses of the detailed design and subsequent fabrication and assembly, test, and inspection of the LADEE Integrated S-Band STDN Transponder Component shall result, as a minimum, in the following technical documentation, as required in the Contract. Contractor format is suitable for this documentation.

3.2.1 Interface Control Document (ICD)

The Contractor shall provide a document or documents that define, in detail, all performance, functional, environmental specifications, and all electrical and mechanical interfaces. Within the electrical information the ICD shall specifically provide –

1. **Interface Block Diagram**
   Provide a block diagram showing the data and power interface signals required for operation. For each interface signal, this includes the type of signal (e.g. power, discrete in/out, analog in/out, serial in/out, differential in/out, etc), signal name, voltage level, frequency, and current. Show the interface connectors for terminating the interface signals. Include any operation and/or survival heaters and temperature sensors.
2. **Power Interface Block Diagram and Grounding Plan**
   Provide a block diagram showing the power input circuitry that shows primary and secondary voltages, filters, converters, and the relationship among primary, secondary and chassis grounds.
3. **Current Profile**
   Provide profile of current versus time from start-up to operations for all power services with detail for in-rush current and settling time.
4. **Connectors, Backshells, Connector Savers List**
   Provide manufacturer and part numbers and masses of interface connectors, backshells and connector savers.

5. **Cable Harness List**
   Provide wiring diagrams, specifications, component data sheets and masses of cable harnesses.
6. **Electrical Drawings**
   Provided end-to-end electrical schematic and wiring diagram of electrical and electronic components.
7. **Data and Specification Sheets**
   Provide vendor specification and data sheets for all electrical and electronic components.

Thermal interface information shall include thermal coatings on exterior surfaces and internal telemetry locations. Draft, preliminary and final reports shall be provided in accordance with the LADEE Deliverable Items List and Schedule.

3.2.2 Drawing Package

The contractor shall provide a drawing package that includes, but is not limited to:

ELECTRICAL:	Assembly and interface drawings (board level schematics available on request)
MECHANICAL:	Assembly and interface drawings
SOFTWARE:	Flowcharts, control logic, architecture, and structure of embedded software

Preliminary and final reports shall be provided in accordance with the Lunar Atmosphere & Dust Environment Explorer (LADEE) Deliverable Items List and Schedule; Appendix D.

3.2.3 Systems Requirement Review Presentation Package

The contractor shall provide a Systems Requirement Review Presentation Package prior to the design program per the contract schedule. The Systems Requirement Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance (QA) activities outlined in this SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification in sufficient detail to ensure that the design will conform to all requirements and is ready for contractor design activities to begin. The presentation shall clearly establish, define, and delineate the requirements, technical approach, proposed modifications, implementation approach schedule, and cost estimate validation to meet the requirements. The intent is to determine that the contractor initial design will align with the requirements and intent of the SOW and Performance Specification. At a minimum, the design and presentation package should cover the following areas to the current level of design at the time of the SRR presentation:

- Program Management review and compliance to SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification
- Current understanding of LADEE specific Integrated S-Band STDN Transponder Component requirements
- Initial documentation tree
- Flight heritage assessment, including identification of expected modifications to base circuits and elements to meet requirements

- Detailed specification review of S-Band STDN Transponder system and components, including electrical, mechanical and environmental test requirements Preliminary Performance Analysis
- Preliminary architectural block diagrams for the different deliverable units
- Requirement compliance matrix, including environmental requirements (also include rationale statement/data for compliance)
- Preliminary Verification test plan (including performance test description and verification methodology matrix)
- Preliminary parts/components list
- Parts sparing philosophy
- Radiation hardness assessment approach
- Preliminary product pricing approach, cost, and cost center presentation
- Preliminary product delivery approach and schedule
- Potential delivery schedule optimizations and risks
- Facility Capabilities Overview
- Overview of Planned Materials and Processes
- Quality Assurance program review
- Program issues and risk assessment

3.2.4 Preliminary Design Review Presentation Package

The contractor shall provide a Preliminary Design Review Presentation Package prior to the detailed design program per the contract schedule. The Preliminary Design Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance (QA) activities outlined in this SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification in sufficient detail to ensure that the design will conform to all requirements and is ready for detailed design to begin. The presentation shall clearly establish, define, and delineate the requirements, technical approach, modifications, implementation approach schedule, and cost estimate validation to meet the requirements. The intent of the PDR is to precisely determine that the design aligns with the requirements and intent of the SOW and Integrated S-Band STDN Transponder Component Performance Specification. At a minimum, the design package should cover the following areas to the current level of design at the time of the PDR presentation:

- Program Management review and compliance to SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification
- Changes since SRR Baselined system/component specifications (for reference)
- Current understanding of modifications required to base circuits and elements to meet requirements
- Preliminary System Performance Analysis
- Preliminary design description and architectural block diagrams for the different deliverable units
- Preliminary system and component level drawings
- Status of trades, as required
- Updated Requirement compliance matrix, including environmental requirements (also include rationale statement/data for compliance)
- Preliminary ICD Preliminary System performance analyses

- Preliminary Mechanical/Structural design and analyses
- Preliminary Electrical/Power Worst-Case analyses
- Updated Verification test plan, including MIPs, performance test description, and verification methodology matrix
- Preliminary Thermal design and analyses
- Parts, including stress analysis and radiation hardness assessment
- Updated parts sparing philosophy
- List of limited life items
- Preliminary technical review of product circuits and elements
- Updated cost
- Updated Product delivery schedule
- Updated potential delivery schedule optimizations and risks
- Preliminary Manufacturing flow with inspection points
- Preliminary Facility layout for manufacturing and testing
- Preliminary Materials and Processes plans
- QA assessment and performance
- Preliminary QA Plan
- Program issues and risk assessment
- Status of Requests for Action (RFAs)
- Identified hazards or hazardous materials (if any)

3.2.5 Critical Design Review Presentation Package

The contractor shall provide a Critical Requirement Review Presentation Package prior to the manufacturing program per the contract schedule. The Critical Requirement Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance (QA) activities outlined in this SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification (SPEC-003.LADEE.ITPSD**)** in sufficient detail to ensure that the design conforms to all requirements and is ready for fabrication to begin. The presentation shall clearly establish, define, and delineate the requirements, technical approach, modifications, implementation approach schedule, and cost estimate validation to meet the requirements. The intent of the CDR is to precisely determine that the detailed design aligns with the requirements and intent of the SOW and Performance Specification prior the beginning of manufacturing. At a minimum, the design and presentation package should cover the following areas to the current level of design at the time of the CDR presentation:

- Program Management review and compliance to SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification
- Changes since PDR
- Baselined system/component specifications (for reference)
- Final list of all modifications required to base circuits and elements to meet requirements
- Detailed design description and architectural block diagrams for the different deliverable units
- Detailed system and component level drawings

- Status of trades, as required
- Updated Requirement compliance matrix, including environmental requirements (also include rationale statement/data for compliance)
- Baselined ICD
- Updated System performance analyses
- Updated Mechanical/Structural design and analyses
- Updated Electrical/Power Worst-Case analyses
- Baselined Verification test plan, including performance test description and verification methodology matrix
- Updated Thermal design and analyses
- Parts, including stress analysis and radiation hardness assessment
- Updated parts sparing philosophy
- List of limited life items
- Detailed technical review of product circuits and elements
- Updated cost
- Updated Product delivery schedule
- Updated potential delivery schedule optimizations and risks
- Updated Manufacturing flow with inspection points
- Updated Facility layout for manufacturing and testing
- Updated Materials and Processes plans
- QA assessment and performance
- Baselined QA Plan
- Program issues and risk assessment
- Status of Requests for Action (RFAs)
- Indentified hazards and hazardous materials (if any)

3.2.6 Pre-Environmental Review Presentation Package

The contractor shall provide a Pre-Environmental Requirement Review Presentation Package prior to the beginning of the environmental test program per the contract schedule. The Pre-Environmental Requirement Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance (QA) activities outlined in this SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification in sufficient detail to ensure that the proposed design conforms to all requirements and is ready for fabrication to begin. The presentation shall clearly establish, define, and delineate the requirements, technical approach, modifications, implementation approach schedule, and cost estimate validation to meet the requirements. The intent of the PER is to precisely determine that the manufactured hardware and testing program aligns with the requirements and intent of the SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification and to demonstrate readiness to begin environmental testing. At a minimum, the presentation package should cover the following areas:

- Program Management review and compliance to SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification
- Changes since CDR

- Overview of test objectives
- Details of test flow
- Describe any known deficiencies and potential impacts on outcome of tests
- Readiness of test facilities, GSE, procedures and personnel
- Describe processes being followed (e.g., internal company standard)
- QA participation

3.2.7 Pre-Ship Review Presentation Package

The contractor shall provide a Pre-Ship Requirement Review Presentation Package prior to shipment of the manufactured hardware per the contract schedule. The Pre-Ship Requirement Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance (QA) activities outlined in this SOW and the LADEE Integrated S-Band STDN Transponder Component Performance Specification in sufficient detail to ensure that the proposed design conforms to all requirements and is ready for fabrication to begin. The presentation shall clearly establish, define, and delineate the requirements, technical approach, modifications, implementation approach schedule, and cost estimate validation to meet the requirements. The intent of the PSR is to precisely determine that the manufactured hardware aligns with the requirements and intent of the SOW and Performance Specification and is ready to for transfer to NASA/ARC COTR control. At a minimum, the presentation package should cover the following areas:

- Program Management review and compliance to SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification
- Baselined system/component specifications and ICDs
- Proof of compliance with SOW and Requirements (incl. verification compliance matrix)
- As-Built Materials List (ABML)
- Proof system will perform in operational environment (Performance analysis, trending, and summary (CPTs and LPTs); environmental test results and model correlation)
- Final mechanical, structural, electrical and thermal design analyses
- As-built design overview
- Final test reviews
- Waivers, Deviations, Non-Conformance Reports
- Status of anomaly reports, discrepancy reports, Requests for Action
- Identification of operational limitations and constraints
- Readiness for shipping (component, shipping containers, paperwork, etc)
- Hazardous materials (if any)

3.2.8 Data Delivery Package

The Data Delivery Package shall be made available for review during mandatory inspections and pre-ship reviews for each of the different hardware deliverables. This package shall also be delivered with each end item with the level of detail required of that item. The package should be comprised of, but not limited to, the following data:

All Items:

- As-Built vs. As Designed Parts List, (includes serialization/revisions)
- Final Drawing Package (including rework instructions, if any)
- Critical Parameters Trend Data,
- Problem/anomaly reporting (complete copies of reports along with status)
- Deviations/Waivers/open items/nonconformances and their dispositions,
- Class I MRBs (complete copies of reports)
- List of Materials and Processes used,
- Log of total operating time,
- List and status of all identified Life-Limited Items,
- Verification compliance matrix, test data and reports,
- Flight connector mate/demate log (Flight Unit only)
- Photograph Documentation (Pre-Closure and Closed)
- Certificate of Conformance
- Performance Analysis Report
- Engineering Analysis Reports (mechanical, structural, electrical and thermal)
- List of Open Items with proposed closure dates
- Thermal model
- Structural model
- Test History Log and Reports
- Command/telemetry Data listing
- Baselined specifications and ICDs
- QA Inspection Reports

3.2.9 Verification Test Plan

A Verification Test Plan shall be generated by the contractor to perform verification tests identified in the requirements in this SOW and the LADEE S-Band STDN Transponder Component Performance Specification. Verification tests must demonstrate acceptable performance over the specified range of performance requirements, measure performance parameters and reveal inadequacies in manufacturing and assembly such as workmanship or material problems.

The LADEE Environmental Verification Specification (T05.LADEE.EVS) shall be used as a guideline in preparing adequate environmental verification test provisions in conjunction with this SOW and the LADEE S-Band STDN Transponder Component Performance Specification.

The plan should state the purpose of each test, state acceptance criteria, describe in detail the test method and instrumentation, and give the sequence of the tests. The plan should include a test matrix summarizing all tests that will be performed on the Integrated S-Band STDN Transponder Component.

The test organization shall be defined, including definition of personnel authority and responsibility. Key facilities that are required for each test shall be identified, with particular attention paid to special facilities that may be resource constrained or only available at a subcontractor's facility. Contractor format is acceptable.

This plan shall be a contractor controlled document and shall indicate all changes made after the initial approval by the ARC. After verification test plan approval, no changes shall be made without written NASA/ARC COTR approval.

3.2.10 Verification Test Procedures

The contractor shall generate Verification Test Procedures. The verification procedures shall be step-by-step instructions for performing tests outlined by the Verification Test Plan. The procedures should define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail limits. Test procedures shall also include Safe-to-Mate procedures to verify that GSE can safely be mated to interfaces and that interfaces are safe to accept mating with the GSE.

Verification test procedures shall be contractor controlled documents and shall indicate all changes made after the initial release for review to the NASA/ARC COTR. Any additional changes shall be provided to the COTR for review.

3.3 Thermal Analysis

The contractor shall perform a thermal analysis to assess the thermal design of the Flight Qualifiable Engineering Unit and Flight Unit Integrated S-Band STDN Transponder Component. The contractor thermal analysis must show that the device and/or the electronic part junction temperatures are within the EEE parts de-rating guidelines for operation in a vacuum environment. The analysis shall consider the maximum and minimum operating temperatures to which the Integrated S-Band STDN Transponder Component will be exposed. The analysis shall combine the worst-case power dissipation of the Integrated S-Band STDN Transponder Component with the worst-case interface temperature. The analysis shall combine maximum power dissipation with maximum interface temperature. In addition, hot and cold survival temperatures at the interface must be specified and tested by the vendor.

The results of these analyses shall be summarized in a Contractor-format for the Thermal Analyses Report, which shall be provided for review as per the contract schedule. LADEE Thermal requires an analysis report at PDR, CDR, and at PSR. The thermal analysis shall contain inputs from the sections 3.3.1 through 3.3.5 unless written agreement with the NASA/ARC COTR supersedes this requirement.

3.3.1 Thermal Model

The Contractor shall provide a reduced thermal model in thermal desktop format or equivalent. ProE. Step files with a description of the conductor network (such as SINDA models) are acceptable if no thermal desktop or equivalent thermal model is available.

The thermal model will include an adequate level of detail to predict, under worst case hot, cold, and safe-hold conditions, all critical temperatures, including those that drive operational and survival temperature limits and heater power. Worst-case conditions will include a

rational combination of the effects of design tolerances, fabrication uncertainties, material differences, and degradation due to aging. Models should use conservative property values for conduction, emission, and multi-layer insulation (MLI) effective emittance, and consider contact resistance.

3.3.2 Thermal Model Documentation

This model shall identify the nodalization, the thermal couplings and masses such that the ARC can recreate the model in the SINDA thermal analyzer.

Thermal model documentation shall include, but not necessarily be limited to, the following information:

1) Graphical figures showing node locations and coordinate system
2) Graphical and/or table showing surface coatings matched to node numbers
3) Tables providing the following information
   a) Nodal thermal capacitance
   b) Linear node-to-node conductors
   c) Fixed radiation node-to-node conductors (if any)
   d) Array data (e.g., temperature dependent properties, time varying power arrays, etc.)
   e) Listing of nodes where operational and survival heater power is to be applied, associated nodes used for heater control, maximum heater power, heater ON/OFF set points, type of heater (bang-bang or proportional), and mission mode power profiles
   f) Detailed description of any special logic/algorithms utilized (e.g., heater control logic, Variable Conductance Heat Pipe [VCHP] logic, Capillary Pumped Loop [CPL]/Looped Heat Pipe [LHP] logic, etc.). No proprietary code will be allowed
   g) Detailed description of logic and use for any user provided subroutines
   h) Listing of component power dissipations and the nodes they are applied to
   i) Listing of materials used along with their applicable thermo-optical and material properties
   j) Listing correlating thermal model node(s) to each reference location where a monitored temperature sensor is placed
4) Listing of temperature limits assigned to monitored temperature sensor(s). The appropriate node number(s) in the thermal model will be identified. The following two types of temperature limits will be provided
   a) Flight Operational limits
   b) Qualification limits

3.3.3 Thermal Testing

All components must be thermally cycled in a thermal vacuum chamber rather than in an air filled chamber. All components shall be flight like blanketed and cycled eight times with the thermal interface held at the qualification temperatures listed above at the thermal interface. Durations shall be four hours. If the component is sensitive to orbit transience, component performance shall be monitored during hot to cold transitions at a rate that a flight like orbit average case might experience. Thermal testing details are provided in the LADEE S-Band STDN Transponder Component Performance Specification.

3.3.4 Hot/Cold Start Requirement

All components shall demonstrate cold start from minimum survival temperature during thermal vacuum testing. Hot/Cold start details are provided in the LADEE Integrated S-Band STDN Transponder Component Performance Specification.

3.3.5 Survival Range Test

All components shall be exposed to hot and cold survival limits at the spacecraft interface during thermal vacuum testing. Survival range test details are provided in the LADEE Integrated S-Band STDN Transponder Component Performance Specification.

3.4 Structural Analysis

A Structural Analysis shall be performed on the Flight Unit structure to ensure the capability to withstand and survive launch and ascent loads. The effects of any thermal inputs shall be reflected in the analyses as appropriate. The results of these analyses shall be summarized in a Contractor format Mechanical Analyses Report that will be provided to the NASA/ARC COTR for review. Associated testing requirements are outlined in the LADEE Integrated S-Band STDN Transponder Component Performance Specification.

4.0 Hardware Manufacture

4.1 Integrated S-Band STDN Transponder Component Assembly

The Contractor shall manufacture and qualify, as appropriate, one (1) Flight Qualifiable Engineering Unit Integrated S-Band STDN Transponder Component assembly and one (1) Flight Unit S-Band STDN Integrated Transponder Component assembly of the selected design. The Integrated S-Band STDN Transponder Component assemblies shall be constructed utilizing parts and materials originating from the same batches and lot dates and use consistent construction and fabrication techniques in their assembly and adjustment, to meet the requirements of the LADEE Integrated S-Band STDN Transponder Component SOW and LADEE Integrated S-Band STDN Transponder Component Performance Specification (SPEC-003-LADEE.ITPSD).

The contractor shall provide separate cost data and schedule impact for performing additional qualification of the Flight Qualifiable Engineering Unit to meet the same qualification as the Flight Unit, along with the latest date, after Receipt of Order (ARO), that this option can be baselined in the requirements with no impact to the Flight Qualifiable Engineering Unit Integrated S-Band STDN Transponder Component assembly delivery date as defined in Table D.1, Hardware Deliverables and Schedules.

Additionally, the contractor shall provide separate comparative cost data and potential schedule impact information related to implementation of contractor selectable options identified in the LADEE Integrated S-Band STDN Transponder Component Performance Specification (SPEC-003-LADEE.ITPSD) for DC Power, Control & Command, and Status Telemetry interfaces.

The contractor shall further provide the latest dates, after Receipt of Order (ARO), that a frequency allocation and any outstanding final parameters identified in the LADEE Integrated

S-Band STDN Transponder Component Performance Specification (SPEC-003-LADEE.ITPSD), such as Uplink Data Rate and Modulation Index related specifications, can be baselined in the requirements with no impact to the delivery date defined in Table D.1, Hardware Deliverables and Schedule.

4.2 Connector Savers

The Flight Qualifiable Engineering Unit, and the Flight Unit, shall be tested with connector savers to minimize mates and demates. Connector savers shall be delivered with each unit.

4.3 Supporting Hardware

The Contractor shall provide the following supporting hardware:

- Two sets of the mating half of the external connectors, with backshells, for each delivered Integrated S-Band STDN Transponder Component assembly unit.
- ESD flight protective caps, as applicable
- Closeout caps for test connectors

The Contractor shall provide up to two, reusable, shipping containers, which will be used to ship the Integrated S-Band STDN Transponder Component assemblies, including hardware accessory and data documentation deliverables.

The shipping containers shall have temperature monitors and recorders, humidity recorders, and be equipped with shock recorders.

4.4 Ground Support Equipment (GSE) & Qualification Support

The Contractor shall provide Ground Support Equipment and equipment qualification support for preliminary compatibility testing and Integration and Test activities at the Benchtop, Spacecraft, and Observatory Integration and Test levels. Ground Support Equipment and Qualification support includes:

- Transport caps
- Ground Test Controller Interface Unit
- Interface Compatibility Test Unit(s) (Loan)
- Transport & Transport Containers for GSE & Equipment Qualification Bench Testing
- Technician Support for Earth Station Compatibility Testing & Spacecraft Integration

The Ground Test Controller Interface Unit shall consist of an EIA 19” rack mountable device and remote cabling package sufficient to power, simulate, and access the full C&DH system interfaces with provision for also introducing external power and signals to operate and validate all modes of the Integrated S-Band STDN Transponder Component assembly’s command, control, and monitoring functions without connection to the LADEE C&DH system in support of ground tests, qualification, and earth station compatibility operations.

The Interface Compatibility Test Unit(s) shall be a loaned component, or components, consisting of a functionally and electrically equivalent S-Band STDN Transponder RF system

core and functionally and electrically equivalent command, control, and monitoring interfaces to those to be utilized on the deliverable end product, that can be utilized, in conjunction with the Ground Test Controller, for initial bench level earth station compatibility testing, as well as initial interface compatibility testing with the LADEE C&DH system in advance of final design acceptance of the Integrated S-Band STDN Transponder Component assembly items.

Transport and reusable transport containers for GSE and equipment qualification bench testing activities shall be provided in support of benchtop interface and earth station compatibility testing activities required to be performed at designated NASA Centers involving the Interface Compatibility Test Unit(s), Ground Test Controller Interface unit, and pre-release versions of Integrated S-Band STDN Transponder Component hardware as required for testing and qualification activities. Events and anticipated locations requiring GSE and pre-release hardware transport and transport containers would include –

- Preliminary C&DH Interface Compatibility Testing at Ames Research Center, CA.
- Preliminary DSN RF Compatibility Testing at Jet Propulsion Laboratory, CA.
- Preliminary SN/NEN RF Compatibility Testing at Goddard Space Flight Center, MD.
- Pre-Release C&DH Interface Compatibility Testing at Ames Research Center, CA.
- Pre-Release DSN RF Compatibility Testing at Jet Propulsion Laboratory, CA.
- Pre-Release SN/NEN RF Compatibility Testing at Goddard Space Flight Center, MD.

The qualification support required for C&DH, earth station compatibility testing and spacecraft integration during development, prior to release, and, after release shall consist of a minimum number of appropriately qualified engineering support personnel hours, resources, and travel able to accompany the Interface Compatibility Test Unit(s), Ground Test Controller Interface Unit, and pre-release Integrated S-Band STDN Transponder Component hardware, prior to final acceptance, in support of required benchtop RF and C&DH compatibility testing mission milestones, as well as, in support of Integration and Test activities at the Spacecraft and Observatory levels as may be required to assure proper operational integration and performance of the deliverables. Events and locations anticipated to require this support be available include -

- Preliminary C&DH Interface Compatibility Testing at Ames Research Center, CA.
- Preliminary DSN RF Compatibility Testing at Jet Propulsion Laboratory, CA.
- Preliminary SN/NEN RF Compatibility Testing at Goddard Space Flight Center, MD.
- Pre-Release C&DH Interface Compatibility Testing at Ames Research Center, CA.
- Pre-Release DSN RF Compatibility Testing at Jet Propulsion Laboratory, CA.
- Pre-Release SN/NEN RF Compatibility Testing at Goddard Space Flight Center, MD.
- Post-Release C&DH Interface Compatibility Testing at Ames Research Center, CA.
- Post-Release DSN RF Compatibility Testing at Jet Propulsion Laboratory, CA.
- Post-Release SN/NEN RF Compatibility Testing at Goddard Space Flight Center, MD.
- Spacecraft Level Transponder Integration & Testing at Ames Research Center, CA.
- Observatory Level Transponder Integration and Testing at Goddard Space Flight Center, MD.

Each event is anticipated to require between 3 and 5 work days for set-up, test, and breakdown to occur.

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be assembled and maintained in such a manner so as to not harm flight items during any interactions. Particular concerns include the use of calibrated equipment, break-out boxes, and harnesses for testing; the use of flight connector savers when interfacing with flight hardware where applicable; and the compatibility of outgassing requirements for anything that will be placed in a thermal vacuum chamber along with flight hardware so that contamination requirements are not compromised. Test setups shall be verified prior to use with flight hardware.

5.0 Software Engineering

5.1 General Requirements

a) The contractor shall provide insight into software development and test activities including: monitoring integration, review of the verification adequacy, review of trade study data and results, auditing the software development and configuration management processes, participation in software reviews, and systems and software technical interchange meetings.

b) The contractor shall provide ARC with all software products and software process tracking information in electronic format, including software development and management metrics.

c) The contractor shall notify ARC, in the response to this solicitation, as to whether open source software will be included in code developed for the project.

d) The contractor shall provide ARC with source code and documentation in electronic format.

e) The contractor shall track all software changes and non-conformances and provide the data to ARC for review.

f) On a monthly basis, the contractor shall provide to ARC metrics to include progress tracking information, software functionality, quality measures, requirements volatility, and software product characteristics.

g) The contractor shall include software traceability data linking requirements, design, software, and tests in the software product documentation.

5.2 Software Process Requirements

a) The vendor shall adhere to the following flight software development process:
- Software Development Planning
- Software Requirements
- Software Design
- Software Development

- Software Test
- Software Delivery
- Software Maintenance and Support

b) During Software Development Planning, the vendor shall provide a Software Development Plan that outlines their approach to:
   - Development and Testing Environment
   - Work Breakdown Structure
   - Quality Management
   - Verification & Validation Approach
   - Customer Involvement
   - Risk Management Approach
   - Security Policy
   - Configuration Management Approach
   - Product Life Cycle description including integration, delivery and maintenance
   - Peer Review/Inspection Processes
   - Software Metrics to be collected

c) During Software Development Planning, the vendor shall provide a detailed schedule sufficient to track the status of the development to within a two-week resolution. The schedule will be maintained throughout the life of the project, and will be used to track the project's progress.

d) During the Software Requirements phase, the vendor shall develop and deliver a Software Requirements Document. The Software Requirements Document shall include:
   - Functional Requirements
   - Required states and modes
   - External and Internal Interface Requirements
   - Internal Data Requirements
   - Performance and Timing Requirements
   - Fault Management/Safety Requirements
   - Security Requirements
   - Computer Resource Requirements
   - Packaging and Delivery Requirements
   - Traceability, Rationale, and Verification Approach of Requirements

e) During the Software Design phase, the vendor shall develop and deliver a Software Design Document. The software design document shall include:
   - Description of software components including algorithms, data structures, and functional decomposition.
   - Software components' input/output description
   - Architecture/Interrelationships between software components
   - Concept of execution including data flow, control flow, and timing
   - Requirements traceability
   - Component utilization of computer resources

f) During the Software Development phase, the vendor shall provide a Software Acceptance Test Plan that lists out the tests that will be conducted, test procedures, acceptance criteria, and requirements traceability.

g) Upon completion of the Test Phase, the vendor shall provide a Test Report that documents the test and acceptance results.

h) During the Delivery Phase, the vendor shall deliver the completed source code and documentation for the software to NASA.

i) During the Delivery Phase, the vendor shall provide a Software Users Guide. The Software Users Guide shall include at a minimum:
- Summary Information: application, inventory, environment, organization.
- Examples and Procedures for software usage
- Capabilities, conventions, errors and messages
- Assumptions, limitations, safety related items/concerns

j) After Delivery and through to the end of the mission, the vendor shall provide continued support to respond to questions and minor change requests as required from NASA.

6.0 Software Development

6.1 Transponder Support Package (TSP)

a) The Contractor shall acquire and validate an Integrated S-Band STDN Transponder Component Support Package (TSP) compatible with NASA/ARC COTR designated hardware and software.

b) The Contractor shall deliver the Integrated S-Band STDN Transponder Component Flight Qualifiable Engineering and Flight Units compatible with the latest validated version of the TSP.

c) The Contractor shall review TSP updates with ARC when they become available. This includes providing source code and documentation on updates.

d) ARC shall provide direction on TSP version to be loaded into subsequent deliverables.

e) The Contractor shall deliver source code and documentation on features and functions with each delivery.

6.2 Startup ROM Code

a) The Contractor shall develop and deliver Startup Read-Only Memory (SUROM) code to provide startup functionality.

b) The Contractor shall deliver the Flight Qualifiable Engineering Unit loaded with the latest version of the SUROM code.

c) The Contractor shall review SUROM code updates with NASA/ARC COTR when they become available.

d) ARC shall provide direction on SUROM code version to be loaded into subsequent deliverables.

e) The Contractor shall deliver SUROM source code and documentation with each delivery.

6.3 Diagnostic Test Software

a) The Contractor shall deliver diagnostic test software that provides for validation of Integrated S-Band STDN Transponder Component operation.

b) Proposed test software updates shall be reviewed with NASA/ARC COTR.

c) Test software updates in the form of source code and revision notes shall be released when available.

d) Each delivery shall include the latest version of the test software.

6.4 Device Drivers

a) The Contractor shall develop and deliver device driver software for all Integrated S-Band STDN Transponder Component I/O compatible with NASA/ARC COTR hardware and software requirements.

b) The device driver software shall be a function library that supports all hardware functionality specified in this statement of work.

c) The Contractor shall deliver the latest version of the device driver software with the Flight Qualifiable Engineering Unit.

d) The Contractor shall review device driver code updates with ARC when they become available.

e) ARC shall provide direction on device driver code version to be loaded into subsequent deliverables.

f) The Contractor shall deliver device driver source code and documentation with each delivery.

7.0 Quality Assurance

7.1 General Requirements

7.1.1 Quality Assurance Plan/Manual

The contractor shall implement a Quality Management System that meets the intent of the requirements of SAE AS9100B, Quality Management Systems - Aerospace – Requirements (2004) or better or equivalent. The QA manual/plan shall identify the supplier's management, policies, standard practices, job instructions, and work instructions. The manual shall describe requirements for quality, including failure reporting, throughout all areas of contract performance, including fabrication, processing, assembly, inspection, test, packaging, storage, and shipping. The manual shall detail the complete flow of material from receipt to

final shipment and may include flowcharts if available. If workmanship standards and/or manufacturing process differences exist between flight and non-flight hardware, the Quality Manual shall clearly identify these differences. The contractor shall submit a Quality Management Plan to ARC. NASA/ARC COTR shall be notified of any changes to the QA program.

7.1.1.1 Software Assurance Requirements

For the purposes of this section, the term software shall also include firmware, including hardware definition languages used during the design and programming of Field Programmable Gate Arrays (FPGAs).

The contractor shall employ Software Quality Assurance to assure:

a) Standards and procedures for management, software engineering and software assurance activities are defined.

b) All plans (e.g., configuration management, software development plan, etc.) required by the contract are completed and comply with contractual requirements.

c) Standards, design, and code are evaluated for quality and security issues.

d) All software requirements are documented and traceable from system requirements to design, code and test (i.e., a software requirements traceability matrix).

e) Software requirement verification status is updated and maintained via a software requirements verification matrix.

f) Formal and acceptance-level software tests are witnessed.

g) Software products and related documentation (e.g., Version Description Documents and User Guides) have the required content and satisfy their contractual requirements.

h) Reports, schedules and records are reviewed.

7.1.2 Surveillance of the Contractor

The work activities and operations of the contractor, subcontractors, and suppliers are subject to evaluation, review, survey, and inspection by ARC representative.

The contractor shall provide the ARC representative with documents, records, equipment, and workings areas within their facilities that are required by the representative to perform their overview activities.

7.1.2.1 Government Source Inspection

Source inspections are not required by the Government if supplier is QML (Qualified Manufacturers List) certified or if a quality control plan is provided to the Government. Suppliers having QML certification should have at least 1 year remaining on certification as of contract award date for this SOW. Note that up to three Government inspections may be required to address quality control concerns or GIDEP alerts.

7.1.2.2 Contractor Source Inspection

Source inspections are not required by the Contractor if supplier is QML certified or if a quality control plan is provided to the Government. Suppliers having QML certification should have at least 1 year remaining on certification as of contract award date for this SOW. The Contractor may require inspections of subcontractors and suppliers at the discretion of Contractor QA personnel and processes.

7.1.2.3 Government Mandatory Inspection Points (MIPs)

The Government or its representative (which may include contractor or supplier QA personnel) will perform the following MIPs listed below. The government may request additional MIPs if the product fails to meet form, fit or function.

- Inspect 100% solder
- Inspect 100% crimps
- Inspect 100% conformal coating, staking, and potting
- Rework Inspection
- Pre-closure Inspection
- Pre-Ship Inspection / Data Review

7.1.3 Configuration Management

The contractor's Configuration Management (CM) system (available for review on request) shall control the design and hardware/software by means of drawings, specifications, and other documents and shall ensure all applicable changes are reviewed in a systematic manner to determine the validity and impact on performance, schedule, and cost. The contractor's CM system shall have a change classification and impact assessment process that ensures Class I changes are forwarded to the NASA/ARC COTR for approval prior to release/incorporation. Class I changes are defined as changes that affect form, fit, function, external interfaces, or requirements as stated within this document and the LADEE S-Band STDN Transponder Component Performance Specification.

All other changes are considered to be Class II changes and shall be controlled and dispositioned by the contractor. All Class II changes shall be provided monthly to the COTR for review purposes. NASA/ARC reserves the right to review all Class II changes for technical content to ensure the proper classification has been assigned. Any flight item that is found to be non-compliant with the quality, workmanship and performance requirements of the contract shall be dispositioned via a waiver or MRB, unless the affected item is reworked to restore compliance or is replaced with a fully compliant item. The contractor shall submit Waivers and MRB's to the COTR for final approval.

A Contractor QA representative shall be a member of the Configuration Control Board (CCB). The QA activities shall be defined in the Configuration Management Plan and described in detail in the QA Plan. Related portions of the plans shall be cross-referenced.

All Contractor's CM related activities and deliveries shall be done in accordance to the LADEE Project Configuration Management Procedure (C04.LADEE.CM).

The Contractor shall provide a Data Management Plan, which shall be compliant with the LADEE Project Configuration Management Procedure (C04.LADEE.CM).

7.1.4 Anomaly & Problem Reporting

Reporting of hardware anomalies to the NASA/ARC COTR shall begin no later than the first power application or the first cycle/actuation for mechanical items at the start of acceptance testing. The NASA ARC COTR shall be notified within 24 hours of each anomaly.

The Contractor's processes for review, disposition and approval of anomaly reports shall be described in their quality plan/manual or provided as a supplement document. In addition, the contractor's anomaly reporting document shall describe the members of the Material Review Board (MRB) and Failure Review Board (FRB). The MRB and FRB shall include NASA participation. These processes shall ensure that positive corrective action has been taken to preclude recurrence and that appropriate audits and tests are performed to verify the implementation of the corrective action.

The contractor shall routinely inform the LADEE Project (NASA/ARC COTR) of MRB and FRB meeting schedules and agendas with sufficient notice to permit LADEE Project participation if desired by LADEE.

At the contractor's facility, NASA Government representatives may participate in MRB/FRB activities as deemed appropriate by Government management or contract.

The NASA/ARC COTR reserves disapproval rights on MRB and FRB decisions. To assure process consistency, the contractor shall provide the LADEE Project on-line access to their LADEE anomaly-reporting database.

The Contractor shall provide, as part of the monthly report, a list of all open anomaly reports and a separate list of the anomaly reports closed during the month. For each reported anomaly or nonconformance, there shall be a report that documents the investigation and engineering analysis needed to determine the cause and corrective actions to disposition the nonconformance, and identify any closed problem reports that do not have a definitive cause or corrective action. Reports shall be submitted to the NASA/ARC COTR for review and approval of the disposition.

The Contractor shall establish and maintain documented procedures to ensure products or components that do not conform to specific requirements are prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when practical), disposition of nonconforming product, and for notification to the functions concerned.

7.2 System Safety Requirements

The contractor shall supply detailed descriptions of the design, test, operation and inspection requirements for all flight hardware and materials, ground support equipment (GSE), and their interfaces necessary for a valid identification, assessment, control and mitigation of documented hazards. This includes technical information concerning hazardous and safety critical equipment, systems, operations, handling and materials. For all identified hazards, the contractor shall also document hazard controls, verifications and tracking methods.

The contractor shall provide technical support to the LADEE Project for safety working group and technical meetings as necessary in conjunction with TIMs.

7.3 Reliability Requirements

The contractor shall prepare and conduct the following set of reliability analyses.

7.3.1 Electrical, Electronic, and Electromechanical (EEE) Parts Stress Analyses

The contractor shall perform parts stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices as employed in the circuit designs of the Flight Item to certify conformance with the de-rating requirements of EEE parts. The analyses shall be documented, and justification shall be included for all applications that do not meet the de-rating criteria. The Contractor shall use NASA document EEE-INST-002, Instructions for EEE Parts Selection, Screening, Qualification, and De-rating to establish criteria. Contractor de-rating guidelines may be considered in place of EEE-INST-002 guidelines but shall be submitted for approval. This analysis shall be provided to the NASA/ARC COTR for review.

7.3.2 Worst Case Analyses

The contractor shall perform worst-case parameter analyses on performance critical or functional critical components for which excessive operating variations could compromise mission performance. The analyses shall validate timing parameters and functionality over combine worst-case radiation effects, temperature, and supply voltage. This should include a signal integrity analysis for each board and for the box as a whole.

The contractor shall identify the worst case analyses planned to assure the design meets critical performance and life requirements. Adequate margins in electronic circuits, optics, electromechanical devices, or other mechanical items (mechanisms) can be verified by analysis, testing, or both. When verification by analysis is used, the analyses shall consider all parameters at worst-case limits and worst-case environmental conditions for the parameter or operation being evaluated. Similarly, when verification by testing is used, the testing shall be conducted to provide as direct a measure as possible of the critical performance or function while the element is subjected to worst-case parameter variations. Elements that may warrant worst case analysis may include: control loops that require adequate phase and gain margin to operate properly, sensitive analog circuitry, power supply or switching circuitry, motor and actuator systems, electro-mechanical elements that require torque margin to operate over life and environmental variations. Preliminary and final reports shall be provided in accordance with the LADEE Deliverable Items List and Schedule.

Worst-case analysis must be performed at a minimum where circuit and EEE parts used in the circuit do not meet or exceed derating criteria as specified in EEE-INST-002. Worst-case analysis is not required where design margin can be demonstrated by analysis.

7.3.3 Reliability Predictions

The contractor shall provide, for review, numerical reliability assessments of the design using reliability prediction techniques that include Reliability Block Diagrams (RBDs). MIL-STD-756, "Reliability Modeling and Prediction" provides guidelines for developing reliability predictions. The predictions may use all available failure rate data, performance data, and/or failure estimates. When estimating electrical, electronics or electromechanical failures, methods and techniques based on MIL-HBK-217 are the preferred approach. The Reliability Prediction report shall include rationale for the use of other methods or techniques, as needed. The contractor shall describe the level of detail of modeling or estimating that is considered suitable for performing the intended quantitative analysis.

7.3.4 Limited-Life Items

The contractor shall identify and manage limited-life items. Limited-life items include all hardware that is subject to degradation because of limited shelf life or expected operating times or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. Preliminary and final reports shall be provided in accordance with the LADEE Deliverable Items List and Schedule.

The LADEE Project COTR shall approve the use of an item whose expected life is less than twice the mission design life.

7.4 Ground Support Equipment (GSE)

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be assembled and maintained to mitigate potential risk to flight hardware. Parts and materials selection and reporting requirements are exempted as long as deliverable flight item contamination requirements are not compromised. However, all GSE interfaces to flight hardware shall be flight quality (i.e. connectors, baseplates, etc.) materials, and cleanliness. See Section 4.4.

7.5 Design Verification Requirements

7.5.1 Verification Requirements

The Contractor shall implement a program to verify all requirements specified in the LADEE S-Band STDN Transponder Component Performance Specification.

The Contractor shall provide a verification matrix defining the method of verification for each specific requirement of this contract. Verification methods shall include:

- **Inspection**: Designated as (I) and represents inspection of the physical hardware by a customer appointed qualified inspector for compliance.

- **Analysis**: Designated as (A) and represents documentation of performance or function through detailed analysis using all applicable tools and techniques.
- **Test**: Designated as (T) and represents a detailed test of performance and/or functionality throughout a properly configured test setup where all critical data taken during the test period is captured for review.
- **Demonstration**: Designated as (D) and represents a detailed test demonstrating functionality to meet requirements with a properly configured test setup where all critical data are taken during the test period and captured for review. Background documentation on the setup shall be required prior to the demonstration.

In-process production evaluation tests, and environmental stress screening tests shall also be considered to be verification tests.

Protoflight test levels and durations shall be used for all Integrated S-Band STDN Transponder Component testing.

7.5.2 Analysis / Trending / Reporting Of Test Data

The Contractor shall properly record, maintain and analyze test information during the normal test program to assess performance and flight worthiness and to aid in the identification and analysis of flight hardware failures and problems.

The Contractor shall also perform trend analyses to track measurable parameters that relate to performance stability and repeatability. The contractor shall analyze collected test data to verify performance and document the data and analysis in a test report or trend analysis report that is delivered as part of the Data Delivery Package. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing through the system integration and test (I&T) phases. These parameters will be compiled in a Trended Parameters List (TPL).

The Performance Analysis Reports will be delivered as part of the Data Delivery Package and presented at formal technical reviews as appropriate.

7.5.3 Demonstration of Failure-free Operation

The Contractor shall have demonstrated a period of 100 hours of contiguous failure-free operation for each Integrated S-Band STDN Transponder Component Unit prior to delivery.

7.6 Workmanship Standards and Processes

7.6.1 Workmanship: Use of Alternate Workmanship Standards

ARC recognizes that the contractor may have an established workmanship program equivalent to the specific standards cited herein. In these instances, the contractor may use existing standards upon review and approval by the NASA/ARC COTR. It must be established that the developer's workmanship program fully encompasses the specific requirements of this section. It is the contractor's responsibility to list all deviations from the baseline workmanship standards and to provide data supporting their position/rationale. In

instances where differences exist, the developer shall provide the details and rationale for their approach.

7.6.2 Training and Certification of Contractor Personnel

All personnel performing work on flight hardware requiring a prerequisite set of skills and competency shall be certified as having completed the required training, appropriate to their involvement.

7.6.3 Hardware Handling, Cleaning and Packaging

Qualified personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging, and purging shall perform the handling of flight hardware. Compatible packaging shall be selected so that hardware is not contaminated or otherwise degraded during shipping or storage. All personnel working on flight hardware shall be certified as having completed the required training and competency certifications prior to handling any flight hardware. This includes, but is not limited to, workmanship, clean room and ESD awareness courses.

Products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, excessive condensation and moisture, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance. A certification log or traveler with all data from the assembly to delivery shall be delivered as part of Deliverable Items List and Schedule package. The material certifications shall also be a part of the Deliverable Items List and Schedule. A DD-250 form is required, which documents the official delivery of hardware, with QA signatures to formally accept the delivery.

The completed parts shall be marked in accordance with MIL-STD-130L, and shall include but not be limited to the following:

1) Vendor Part Number
2) Vendor Name
3) Vendor Serial Number
4) Contract Number
5) Unit Name
6) Weight

7.6.3.1 Shipping

Contractor shall be responsible for providing an acceptable shipping container that protects the hardware appropriately for all environments the hardware may encounter.

While in a shipping container, the Integrated S-Band STDN Transponder Component (Flight Qualifiable Engineering and Flight Units) shall be wrapped in a non-ESD-generating vapor barrier with redundant maximum humidity indicators.
The shipping container shall also include shock indicators and shall be capable of prolonged shipping conditions, if necessary. The Contractor shall document what action NASA ARC is

to take if the sensors are tripped when hardware arrives at the NASA ARC receiving area. A copy of this document shall be included with shipping documentation.

By executing the act of product shipment, the supplier certifies that the product complies with all purchase order requirements. Prior to shipping, quality assurance personnel shall ensure that:

- Fabrication, inspection, and test operations have been completed and accepted.
- All products are identified and marked in accordance with requirements.
- The accompanying documentation (developer's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals.
- Evidence exists that preservation and packaging are in compliance with requirements.
- Packaging and marking of products, as a minimum comply with Interstate Commerce Commission rules and regulations and are adequate to ensure safe arrival and ready identification at their destinations.
- The loading and transporting methods are in compliance with those designated in the shipping documents.
- Integrity seals are on shipping containers and externally observable shock monitors do not show excessive environmental exposure.
- In the event of unscheduled removal of a product from its container, the extent of re-inspection and retest shall be as authorized by NASA or its representative.
- Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors, are provided where appropriate.

The contractor’s quality assurance organization shall verify prior to shipment that the above requirements have been met and shall sign off appropriate shipping documents to provide evidence of this verification.

The contractor shall ship F.O.B. Destination.

7.6.4 Electrostatic Discharge Control Requirements

The Contractor shall document and implement an ESD Control Program suitable to protect the most ESD-sensitive instrument components at all levels of assembly and integration in accordance with the requirements of ANSI/ESD S20.20 or NASA-STD-8739.7.

All personnel who manufacture, inspect, test or otherwise process electronic hardware or who require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement prior to handling any electronic hardware.

7.6.5 Workmanship Requirements

The following workmanship standards shall apply to printed circuit boards, soldered assemblies, harnessing, and fiber optics.

7.6.5.1 Requirements for Printed Wiring Boards

a) Printed Wiring Board (PWB) Design:
Space Flight PWB designs shall not include features that prevent the finished board(s) from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc.).

- IPC A-600, Guidelines for Acceptability of Printed Boards (Class 3 Requirements
- IPC J-STD-001D, Requirements for Soldered Electrical and Electronic Assemblies
- IPD J-STD-001DS, Space Applications Electronic Hardware Addendum to J-STD-001D Requirements for Soldered Electrical and Electronic Assemblies
- IPC-D-275, Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
- IPC-2223, Sectional Design Standard for Flexible Printed Boards
- IPC-2221, Generic Standard on Printed Board Design (for non-critical ground support equipment only as defined in S312-P-003 paragraph 1.4)
- IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards (for non-critical ground support equipment only as defined in S312-P-003 paragraph 1.4)

b) Printed Wiring Board (PWB) Manufacture:
GSFC S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses (the use of this procurement specification is critical in the procurement of "Flight" and "Critical Ground Support" boards)

- IPC-A-600, Acceptability of Printed Boards
- IPC-6011, Generic Performance Specification for Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
- IPC-6013, Qualification and Performance Specification for Flexible Printed Boards

As per GSFC S321-P-003, the contractor shall provide Flight PWB coupons to the LADEE/ARC COTR, or to an ARC approved laboratory for evaluation. PWB coupon approval shall be obtained from COTR or an ARC approved laboratory prior to population of flight PWBs.

7.6.5.2 Workmanship Requirements

The following workmanship requirements shall apply:

- Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;
- Surface Mount Technology (SMT): NASA-8739.2, Workmanship Standard for Surface Mount Technology;
- Hand Soldering Assemblies: NASA-STD-8739.3 or IPC J-STD-001D/DS, Soldered Electrical Connection

- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;
- Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;

7.6.5.3 New or Advanced Packaging Technologies

Workmanship requirements or standards, including design, qualification, and acceptance requirements, specified by the Contractor for advanced packaging technologies, such as multi-chip modules (MCMs), stacked memories, chip on board, column-grid arrays (CGA) or ball grid arrays (BGA), shall be submitted to the NASA/ARC COTR for review and approval prior to use.

Each Non-Standard Process document shall address process control, fabrication, inspection, training, and acceptance and rejection criteria. Test data and evaluation records shall be submitted as part of the process support for approval, as applicable.

7.7 EEE Parts Requirements

7.7.1 General

All Flight Qualifiable Engineering Unit and Flight Unit parts shall be selected and processed in accordance with the requirements of EEE-INST-002, "Instructions for EEE Parts Selection, Screening, Qualification, and Derating". All application notes in EEE-INST-002 will apply.

Similarly, ARC recognizes that the contractor may have an established parts and materials selection program equivalent to the standards cited herein. It must be established that the developer's part selection program fully encompasses the specific requirements of this chapter and the standard cited. The Contractor's rationale for their part selection program shall be submitted as a report to ARC for review and approval.

The minimum acceptable EEE part grade available for Flight Unit use on LADEE is Class 2 with 100% Particle Impact Noise Detection (PIND) screening for cavity bodied devices and a sample Destructive Physical Analysis (DPA). This assumes that the radiation hardness requirements and system reliability goals are also being met. This would include parts costs, test costs, risk of test failures and reliability differences between both classes. The contractor shall maintain an EEE Parts Identification List and shall review proposed parts with the NASA/ARC COTR. Preliminary and final reports shall be provided in accordance with the LADEE Deliverable Items List and Schedule.

7.7.2 Electrical, Electronic, and Electromechanical (EEE) Parts

All components identified in the Parts Identification List (PIL) are considered EEE parts and shall be subjected to the requirements set forth in this section.

7.7.3 Custom Devices

In addition to the applicable requirements of EEE-INST-002, custom microcircuits, hybrid microcircuits, MCM, ASIC and other non-standard application unique devices planned for use in the Flight Qualifiable Engineering and Flight Units shall be subjected to a parts-level design review and approval by NASA/ARC COTR or ARC representatives. The design review shall address, at a minimum, de-rating of elements, method used to certify acceptable reliability, assembly and materials processes, methods for assuring adequate thermal matching of materials, and screening and qualification requirements.

7.7.4 Plastic Encapsulated Microcircuits (PEMs)

The use of Plastic Encapsulated Microcircuits is discouraged in the Flight Qualifiable Engineering and Flight Units. However, when use is necessary to achieve unique requirements that cannot be found in hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of NASA ARC EEE-INST-002. All PEM(s) require NASA/ARC COTR review and concurrence. PEM usage shall be presented at the Design Conformance Review and TIMs, as applicable.

PEMs usage will be considered on a case-by-case basis. Approval will depend on the heritage of the part, part usage history, space flight history, testing performed by the supplier/manufacturer, assembly environmental stress screening, and available test data.

7.7.5 Radiation Hardness

All Flight Unit parts shall be selected to meet their intended application in the on-orbit LADEE radiation environment as defined in the LADEE Integrated S-Band STDN Transponder Component Performance Specification, SPEC-003.LADEE.ITPSD, and the LADEE Radiation Control Plan (C35.LADEE.RCP). The radiation environment consists of two separate effects: total ionizing dose (TID) and single-event effects (SEE). The Contractor shall document the radiation hardness assessment for each part with respect to both effects and include this assessment as part of the Design Conformance Review Presentation Package. Test plans and reports for parts that require radiation testing shall be submitted to the NASA/ARC COTR for review.

7.7.6 Verification Testing

The contractor shall be responsible for the conduct of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements. Supplier part failures shall be reported to the NASA/ARC COTR within 72 hours of the reported failure. Re-testing of parts to verify vendor screening or qualification tests by re-testing is not required unless other existing evidence or operational history indicates it is necessary, such as failure incident or suspicious failure history, unacceptable performance in similar applications, GIDEP Alerts or other reliability concerns. Re-testing shall be in accordance with EEE-INST-002.

7.7.6.1 Destructive Physical Analysis (DPA)

DPA, per GSFC specification S-311-M-70 or equivalent, shall be performed on each lot of Grade 1, 2, or 3 parts not procured from a military QPL or QML. This requirement applies to

semiconductors, microcircuits, metal film and wire-wound resistors, resistor networks, capacitors, relays, filters, crystal oscillators, fuses, hybrids, MCMs and hybrid oscillators. DPA is not required for composition resistors, monolithic glass capacitors, coils, inductors and transformers. Any lot of parts not meeting the DPA acceptance criteria shall not be used in equipment without procuring activity approval.

7.7.6.2 Particle Impact Noise Detection (PIND)

All EEE devices with internal cavities shall be subjected to 100% PIND screening, in accordance with the applicable specification in EEE-INST-002. Any device failing this screening shall not be used in any flight application. Parts from lots exceeding 20% PIND failure shall be reviewed and approved by NASA ARC or shall not be used. PIND screening is not required for diodes with 'double-plug' type construction

7.7.7 Parts Age Control

Parts more than 5 years old require LADEE COTR concurrence. Contractors shall present justification with inspection and test requirements.

7.7.8 Parts Lists

The contractor shall create and maintain a Parts Identification List (PIL) for the configured EU, and FU articles. The PIL shall be submitted for review and approval. Each parts list shall be an itemization of the EEE parts selected for use in the configured non-flight or flight article. As a minimum, the PIL shall contain the following information:

a) Part number;
b) Generic part number
c) Description;
d) Manufacturer and/or Cage Code
e) Need Quantity

An As-Built Parts List (ABPL) shall also be prepared for the configured flight articles and submitted for review. The ABPL is typically the final PIL with additional as-built information incorporated. As a minimum, the ABPL shall contain the following additional information:

a) Reference Designation
b) Lot/Date Code;

7.7.9 GIDEP Alerts and Problem Advisories

Contractors shall keep sufficient selection and usage records for all flight parts and materials adequate to determine applicability of any issued Government Industry Data Exchange Program (GIDEP) alerts relevant to items used on LADEE. The contractor shall review and disposition all GIDEP Alerts for relevancy and impact. In addition, the contractor shall review and disposition any NASA Alerts and Advisories provided to the developer by the LADEE Project. Alert applicability, impact, and corrective actions shall be documented and status provided to the LADEE Project on a monthly basis.

Any impact of the contract resulting for GIDEP alerts and advisories shall be handled on a case-by-case basis.

7.7.10 Reuse of Parts and Materials

EEE parts and materials, which have been installed in an assembly, and removed for any reason, shall not be used again for flight.

7.7.11 Part Notification of Failure

The contractor shall provide failure-reporting data to NASA/ARC COTR within 72 hours of part failure determination.

7.8 Materials, Processes and Lubrication Requirements

7.8.1 Materials Selection Requirements

The contractor shall implement a Materials and Processes Selection, Implementation, & Control plan per NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft.

To qualify material for flight use, the material must have a satisfactory flight heritage relevant to LADEE requirements or meet the following applicable selection criteria as defined herein for:

- Vacuum outgassing
- Stress corrosion cracking (SCC)
- Lubrication requirements
- Manufacturing process selection
- Fastener integrity

The contractor shall prepare Materials Usage Agreements (MUA) and a Materials Identification and Usage List (MIUL), per NASA-STD-6016, Standard Materials and Processes Requirement for Spacecraft, of all materials planned for use in the configured Flight Unit hardware. The MIUL shall be submitted for review and approval as part of the proposal response. Category I & II MUA require project approval as part of the SOW response review.

The selection and use of material with hazardous properties (such as flammability and toxicity) shall meet the requirements specified in NASA-STD-6001. A material that has limited space flight heritage or does not meet the applicable selection requirements shall be considered non-compliant. If there are no alternatives available to select a compliant material, the material's usage will be justified and approved prior to use for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those data. A Materials Usage Agreement (MUA) shall be submitted to NASA/ARC COTR for approval for use of the proposed non-compliant material. Refer to Appendix B for an example of the LADEE MUA form. The Contractor may use their own forms provided they contain sufficient information and justification.

The MIUL shall be available for review of proposed materials and processes by the NASA/ARC COTR. An As-Built Materials List (ABML) shall be included as part of the end

item data package. Preliminary and final reports shall be provided in accordance with the LADEE Deliverable Items List and Schedule.

Pure Tin, Zinc, and Cadmium are not acceptable for flight use. The use of high purity tin, zinc and cadmium finishes and plating, or the use of Lead-free solder, is prohibited since these are prone to formation of metallic whiskers. Or otherwise mitigate the effects of tin-whisker formation.

7.8.2 Vacuum Outgassing of Polymeric Materials

Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% shall be approved for use in a vacuum environment. Material vacuum outgassing shall be determined in accordance with ASTM E-595. If a material exceeds these maximum limits, the contractor shall be required to either replace with a compliant material or bring it into compliance via a vacuum bakeout, or to submit a Material Usage Agreement (MUA) for its usage. Preliminary and final reports shall be provided in accordance with the Lunar Atmosphere & Dust Environment Explorer (LADEE) Deliverable Items List and Schedule.

7.8.3 Stress Corrosion Cracking of Inorganic Materials

Materials used in structural applications shall be highly resistant to stress corrosion cracking (SCC) as specified in MSFC-STD-3029. A Material Usage Agreement (MUA) and a SCC evaluation form shall be submitted, contractor format acceptable, for each material usage that does not comply with the MSFC-STD-3029 SCC requirements.

7.8.4 Lubrication Systems

The contractor's material list shall include lubrication usage. Lubricants shall be selected for use with materials on the basis of flight heritage and valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination concerns.

All lubricated mechanisms shall be life tested unless it can be established and documented that a valid flight heritage exists to an identical mechanism used in an identical flight application or to an identical mechanism that has been separately qualified by suitable life testing.

7.8.5 Process Selection Requirements

Manufacturing processes (e.g., conformal coating, adhesive bonding, lubrication, heat treatment, welding, chemical or metallic coatings, etc.) shall be carefully selected to preclude unacceptable material property changes during exposure to flight environments that could cause adverse effects to the material and/or to the intended applications. Materials and manufacturing process information shall be provided on the material list.

7.8.6 Fasteners

The contractor shall comply with the procurement and test requirements for flight hardware and critical ground support equipment fasteners contained in 541-PG-8072.1.2, Goddard Space Flight Center Fastener Integrity Requirements. Traceability shall be maintained for every fastener lot. Material certification and test reports for fastener lots shall be on file and available for review upon request.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. On steels harder than RC 33, a plating process that does not embrittle the steel shall be utilized.

7.8.7 Materials Used in "Off-the-Shelf" Hardware

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or replaced shall be treated as non-compliant. The contractor shall submit an MUA (Appendix B) that defines the appropriate measures that will be used to ensure that all materials in the "off-the-shelf" hardware are acceptable for use. It may be possible to replace unknown or non-compliant materials within the hardware with compliant materials, or hermetically seal, or vacuum bake out the questionable hardware to bring the hardware into a suitable condition for use. Such approaches shall be documented in the MUA. When a vacuum bake-out is the selected method, it shall incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the project contamination plan and error budget.

7.8.8 Materials Procurement Requirements

Raw materials purchased by the contractor and its developers shall be accompanied by a Certificate of Compliance and, where applicable, the results of nondestructive, chemical, and physical tests. When requested, this information shall be made available to the NASA/ARC COTR for review. Any deviations of material types must be approved by the NASA/ARC COTR.

7.8.9 Dissimilar Metals

To avoid electrolytic corrosion, dissimilar metals should not be used in direct contact unless protection against corrosion has been provided in accordance with MIL-STD-889. Variances from this policy must be submitted to the government for approval.

7.8.10 Limited-Life Items

The contractor shall identify and manage limited-life items. Limited-life items include all hardware and materials that are subject to degradation because of limited shelf life or expected operating times or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined.

The list of limited-life items shall include devices or components susceptible to aging, wear, fatigue, lubricant loss, or other types of degradation that limits operating life. Records shall be maintained that allow evaluation of the cumulative effect (time and/or cycles) for limited-

life items, starting when useful life is initiated and indicating the conditions, environments, or activity that degrade the performance of the items. The use of an item whose expected life is less than twice the mission design life shall require NASA/ARC COTR approval.

8.0 Contamination Control Requirements

The contractor shall establish the specific cleanliness requirements to minimize performance degradation and delineate the approaches to meet the LADEE Contamination Control Plan (C35.LADEE.CCP).

8.1 Thermal Vacuum Bakeouts

Thermal vacuum bake-out of the Integrated S-Band STDN Transponder Component shall be performed before delivery. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) are specified in the LADEE Integrated S-Band STDN Transponder Component Performance Specification.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) shall be incorporated during all thermal vacuum bakeouts. The QCM shall provide the outgassing rate data during the bakeout. This data shall be recorded and provided in the data package.

Although the thermal vacuum test is normally used for a final bakeout opportunity [usually in the last hot cycle], the individual components should be fully cured and baked out before thermal vacuum testing to minimize the length of time spent in the chamber.

8.2 External Cleanliness

All exterior hardware cleanliness shall be verified to be 450A, as described in IEST-STD-CC1246D, upon delivery to ARC.

9.0 Sparing

The contractor shall provide spares recommendations based on knowledge of procurement lead times, component costs, component availability, and historic failure rates.

The contractor shall describe their parts sparing philosophy, if any, to mitigate effects of a failed part to the delivery schedule defined in Table D.1, Hardware Deliverables and Schedule.

APPENDIX A: Abbreviations and Acronyms

ABBREVIATION/ ACRONYM	DEFINITION
A	Analysis (Verification Matrix Designation)
ABML	As-Built Materials List
ABPL	As-Built Parts List
ANSI	American National Standards Institute
ARC	Ames Research Center
ARO	After Receipt of Order
BBU	Breadboard Unit
BGA	Ball Grid Array
BSP	Board Support Package
C&DH	Command and Data Handling
CDR	Critical Design Review
CGA	Column Grid Array
CM	Configuration Management
CO	Contracting Officer
COTR	Contracting Officer Technical Representative
CVCM	Collected Volatile Condensable Mass
DCR	Design Conformance Review
DPA	Destructive Physical Analysis
DR	Discrepancy Report
DSN	Deep Space Network
EEE	Electrical, Electronic, and Electromechanical
EPS	Electrical Power System
ESD	Electrostatic-Discharge
EDU	Engineering Development Unit
ETU	Engineering Test Unit
EU	Engineering Unit
FMEA	Failure Modes and Effects Analysis
FPGA	Field Programmable Gate Array
FRB	Failure Review Board
FU	Flight Unit
GEO	Geosynchronous Orbit
GIDEP	Government/Industry Data Exchange Program
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
I	Inspection (Verification Matrix Designation)
IAU	Integrated Avionics Unit
ICD	Interface Control Document
ITIM	Initial Technical Interchange Meeting
LADEE	Lunar Atmospheric & Dust Environment Explorer
MCM	Multi-Chip Module

ABBREVIATION/ ACRONYM	DEFINITION
MIL	Materials Identification List
MIP	Mandatory Inspection Point
MRB	Material Review Board
MUA	Materials Usage Agreement
N/A	Not Applicable
NCR	Non-Conformance Report
NEN	Near Earth Network
NRC	National Research Council
PDR	Preliminary Design Review
PEMs	Plastic Encapsulated Microcircuits
PER	Pre-Environmental Review
PIL	Parts Identification List
PIND	Particle Impact Noise Detection
PROM	Programmable Read Only Memory
PSR	Pre-Ship Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCM	Quartz Crystal Microbalance
RBD	Reliability Block Diagram
RF	Radio Frequency
ROM	Read-Only Memory
S/C	Spacecraft
SBC	Single Board Computer
SCC	Stress Corrosion Cracking
SCM	Software Configuration Management
SEE	Single-Event Effects
SMT	Surface Mount Technology
SN	Space Network (TDRSS)
SOW	Statement of Work
SRR	Systems Requirement Review
STDN	Space Tracking & Data Network
SUROM	Startup Read-Only Memory
T	Test (Verification Matrix Designation)
TID	Total Ionizing Dose
TIM	Technical Interchange Meeting
TIR	Technical Information Review
TML	Total Mass Loss
TPL	Trended Parameters List
TRL	Technology Readiness Level
TSP	Transponder Support Package
WVR	Waiver

APPENDIX B: LADEE Material Usage Agreement Form

<table>
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APPENDIX C: List of Referenced Documents

453-HNDK-GN	Ground Network Tracking and Acquisition Data Handbook
453-NENUG	Near Earth Network (NEN) User's Guide
AFSPCMAN 91-710	Air Force Range Safety User Requirements Manual
ANSI/ESD S20.20 1999	Electrostatic Discharge Control
APR 7120.8	Program/Project Reviews for Space Flight Systems
APR 8070.1	Engineering Design Requirements for Space Flight Systems
APR 8070.2	Class D Spacecraft Design and Environmental Test
ANSI/ESD S20.20	Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ASTM E-595	Standard Test Method for Total Mass Loss and Collected Volatile, Condensable Materials for Outgassing
C01.LADEE.SMAIP	LADEE System Safety and Mission Implementation Plan
C03.LADEE.SEMP	Systems Engineering Management Plan (Appendix F)
C14.LADEE.EMI/EMC	LADEE Electromagnetic Interference and Compatibility Control Plan
C35.LADEE.CCP	LADEE Contamination Control Plan
C35.LADEE.RCP	LADEE Radiation Control Plan
CCSDS 101.0-B-6	Consultative Committee for Space Data Systems Telemetry Channel Coding Blue Book
DSN 810-5	DSN/Flight Project Interface Design Handbook
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and De-rating
ICD-002.LADEE.EPS	EPS – LADEE Interface Control Document
IEST-STD-CC1246	Product Cleanliness Levels and Contamination Control Program
IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-6011	Generic Performance Specification for Printed Boards
IPC-6012	Qualification and Performance Specification for Rigid Printed Boards
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC-A-600	Acceptability of Printed Boards
IPC-D-275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
ISBN 0-16-016464-8	Manual of Regulations and Procedures for Federal Radio Frequency Management
J-STD-001D (001DS)	Requirements for Soldered Electrical and Electronic Assemblies
MIL-B-5087	Bonding for Aerospace Systems (Replaced by MIL-STD-464A)

MIL-C-39012	Connectors, Coaxial, Radio Frequency (Replaced by MIL-PRF-39012)
MIL-DTL-45204	Detail Specification Gold Plating, Electrodeposited
MIL-G-45204	Military Specification Gold Plating, Electrodepositied (Replaced by MIL-DTL-45204)
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification
MIL-HBK-217	Reliability Modeling and Prediction
MIL-STD-461F	Control of Electromagnetic Interference
MIL-STD-464A	Military Standard, Electromagnetic Environmental Effects, Requirements for Systems
MIL-STD-882	Standard Practice for System Safety
MIL-STD-889	Dissimilar Materials
MIL-STD-975	NASA Standard Electrical, Electronic and Electromechanical (EEE) Parts List
MSFC-STD-3029	Selection of Metallic Materials for Stress Corrosion Cracking Resistance
NASA-STD-6001	Flammability, odor, off-gassing and compatibility requirements & test procedures for materials in environments that support combustion
NASA-STD-6016	Standard Materials and Processes Requirement for Spacecraft
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Soldered Electrical Connections
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring
NASA-STD-8739.5	Fiber Optic Terminations, Cable Assemblies, and Installation
NASA-STD-8739.7	Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)
NPR-7150.2	NASA Software Engineering Requirements
NPR-8715.3	NASA General Safety Program Requirements (with chg4)
RSM 2002B	Range Safety Manual, WFF; Revision B
S311-M-70	Destructive Physical Analysis
S312-P-003	Procurement Specification for Rigid Printed Boards for Space Flight Applications and Other High Reliability Uses
SAE AS 9100B	Quality Systems Aerospace Model for Quality Assurance in Design, Development Space Flight Applications and Other High Reliability Uses
SPEC-003.LADEE.ITPSD	LADEE Integrated S-Band STDN Transponder Performance Specification
T01-004.LADEE.MSRD-L4	LADEE Mechanical Systems Requirements Document
T01-006.LADEE.SMAR	LADEE System Safety and Mission Assurance Requirements
T01-007.LADEE.TCSR	LADEE Thermal Control Subsystem Requirements Document

T05.LADEE.EVS	LADEE Environmental Verification Specification (Tailored APR 8070.2)

APPENDIX D: Deliverable Items Lists and Schedules

In the event of a conflict between this appendix and the Statement of Work (SOW) regarding identification of deliverables, quantities, references, or delivery dates, the Statement of Work (SOW) language shall take precedence.

D.1 Hardware Deliverables and Schedules

Item #	Description	Reference	Quantity / Unit	Delivery Date
1	Flight Qualifiable Integrated S-Band STDN Transponder Component Engineering Assembly	SOW Section 4.1	1 Each	Within Twelve (12) months after Award of Contract
2	Flight Qualified Integrated S-Band STDN Transponder Component Assembly	SOW Section 4.1	1 Each	Within Twelve (12) months after Award of Contract
3	Connector Savers	SOW Section 4.2	1 Each for every external connector	with Item #1 and #2
4	Mating Half of External Interface Connectors & Backshells	SOW Section 4.3	2 Each for every external connector of each Integrated S-Band STDN Transponder Component Assembly	Within Six (6) months after Award of Contract
5	Electrostatic Discharge (ESD) Caps	SOW Section 4.3	1 Each for every external connector.	with Item #1 and #2
6	Closeout Caps	SOW Section 4.3	1 Each for every test connector	with Item #1 and #2
7	Transponder Shipping Containers	SOW Section 4.3	1 Each for each Integrated S-Band STDN Transponder Component Assembly	with Item #1 and #2

8	Transport Caps	SOW Section 4.4	1 Set for each Integrated S-Band STDN Component Assembly	With Item #1 and 2
9	Ground Test Controller Interface Unit for Integrated S-Band STDN Transponder Component Assembly	SOW Section 4.4	1 Each	Within Six (6) months after Award of Contract
10	Interface Compatibility Test Unit(s) (Loan)	SOW Section 4.4	1 Lot	Within Six (6) months after Award of Contract
11	Ground Support Equipment (GSE) Shipping Containers	SOW Section 4.4	1 Each as appropriate for each GSE item; Ground Test Controller Interface Unit, Interface Compatibility Test Unit(s),	Within Six (6) months after Award of Contract

D.2 Information and Data Documentation Deliverables and Schedules

This section provides a tabular listing of information and documentation deliverables, including the following information:

Description: This provides the Title of the deliverable item.

Reference: This provides the reference back to the pertinent document calling out the deliverable.

Category:

A = Approval: Documents in this category require approval from the National Aeronautics and Space Administration (NASA)/Ames Research Center (ARC) Contracting Officer (CO). In general, documents shall be provided in contractor format as long as required content is addressed. The NASA/ARC CO reserves the time-limited right of disapproval for each submission. The time-limited period is two weeks from receipt of documents.

R= Review: Documents in this category do not require formal NASA/ARC CO approval. They must be received within a specified time period and are subject to evaluation.

I = Information: Documents in this category are informal and are for information only.

Quantity: This provides the required number of copies for the deliverable. All data is required to be submitted electronically and in native file formats unless directed otherwise. The number in the quantity column refers to the number of hard copies required.

Delivery Date: This provides the fixed or relative date or time that the deliverable is required.

Item #	Description	Reference	Category	Quantity	Delivery Date
1	Additional Cost and Latest Date ARO Flight Qualification Testing can be Baselined for Hardware Deliverable Item 1 without Impact to Delivery Date	SOW Section 4.1	I	N/A	At Award of Contract
2	Cost Comparison Data, Potential Schedule Impacts, & Latest Date ARO Selectable DC Power, Control, & Telemetry Options can be Baselined without Impact to Hardware Deliverable Items 1 & 2 Delivery Date	SOW Section 4.1	I	N/A	At Award of Contract

3	Latest Date ARO Frequency Allocation & Remaining Outstanding Uplink Data Rate & Mod. Index Final Parameters can be Baselined without Impact to Hardware Deliverable Items 1 & 2 Delivery Date	SOW Section 4.1	I	N/A	At Award of Contract
4	Monthly Status Report (MSR)	SOW Section 2.1	I	1	Within ten (10) calendar days following the month being reported or sooner
5	Initial Technical Interchange Meeting	SOW Section 2.3.7	I	1	Within one and one half (1.5) weeks after Award of Contract
6	System Requirements Review (SRR)	SOW Section 2.3.1	R	1	Within three (3) weeks after Award
7	Preliminary Design Review (PDR)	SOW Section 2.3.3	A	1	Within one and one half (1.5) months after Award of Contract
8	Preliminary Design Review Report	SOW Section 2.3.3	A	1	Within ten (10) calendar days after completion of PDR
9	Critical Design Review (CDR)	SOW Section 2.3.4	R	1	Within two (2) months after PDR
10	Critical Design Review Report	SOW Section 2.3.4	A	1	Within ten (10) calendar days after completion of Critical Design Review (CDR)
11	Pre-Environmental Review (PER)	SOW Section 2.3.5	A	1	Within five (5) calendar days before start of environmental testing on Qualified Unit

12	Pre-Shipment Review (PSR)	SOW Section 2.3.6	A	1	Within five (5) calendar days prior to delivery of each Qualification and Flight Unit
13	Preliminary Interface Control Document (ICD)	SOW Section 3.2.1	A	3	Within fifteen (15) calendar days before PDR
14	Draft Interface Control Document (ICD)	SOW Section 3.2.1	R	1	Within 30 calendar days after contract award
15	ICD (Final)	SOW Section 3.2.1	A	3	Within fifteen (15) calendar days before CDR
16	Preliminary Drawing Package	SOW Section 3.2.2	R	3	Within fifteen (15) calendar days before PDR
17	Drawing Package (Final)	SOW Section 3.2.2	A	3	Within fifteen (15) calendar days before CDR
18	Preliminary Design Review Presentation Package	SOW Section 3.2.4	I	5	Within fifteen (15) calendar before PDR
19	Critical Design Review Presentation Package	SOW Section 2.3.4	I	5	Within fifteen (15) calendar before CDR
20	Flight Unit Data Delivery Package	SOW Section 3.2.8	A	1	With each delivered Transponder
21	Close Out Photos	SOW Section 3.2.8	R	1	Due at PSR
22	Preliminary Verification Test Plan	SOW Section 3.2.9	R	3	Within fifteen (15) calendar days before PDR
23	Verification Test Plan (Final)	SOW Section 3.2.9	A	3	Within fifteen (15) calendar days before CDR

24	Verification Test Procedures	SOW Section 3.2.10	A	3	Within thirty (30) calendar days before start of testing and as changes occur.
25	Preliminary Thermal Analysis	SOW Section 3.3	R	2	Within fifteen (15) calendar days before PDR
26	Thermal Analysis (Final)	SOW Section 3.3	A	2	Within fifteen (15) calendar days before CDR
27	Preliminary Reduced Thermal Model	SOW Section 3.3.2	R	2	Within fifteen (15) calendar days before PDR
28	Final Reduced Thermal Model	SOW Section 3.3.2	A	2	Within fifteen (15) calendar days before CDR
29	Final Detailed Thermal Model	SOW Section 3.3.2	A	2	Within fifteen (15) calendar days before CDR
30	Preliminary Structural Analysis	SOW Section 3.4	R	2	Within fifteen (15) calendar days before PDR
31	Structural Analysis (Final)	SOW Section 3.4	A	2	Within fifteen (15) calendar days before CDR
32	Software Development Plan	SOW Section 5.2b	A	2	During Software Development planning
33	Software Development Detailed Schedule & Updates	SOW Section 5.2c	R	2	Monthly throughout Software Development planning
34	Software Requirements Document	SOW Section 5.2d	A	2	During Software Requirements Phase
35	Software Design Document	SOW Section 5.2e	R	2	During Software Design Phase
36	Software Acceptance Test Plan	SOW Section 5.2f	R	2	During Software Development phase

37	Software Test Report	SOW Section 5.2g	R	2	Upon Software Test Phase completion
38	Completed Software Source Code & Documentation	SOW Section 5.2h	R	2	During Software Delivery Phase
39	Software User's Guide	SOW Section 5.2i	R	2	During Software Delivery Phase
40	TSP Source Code & Documentation	SOW Section 6.1e	R	2	As part of each TSP delivery
41	Startup Read-Only Memory (SUROM) Code & Documentation	SOW Section 6.2e	R	2	As part of each TSP delivery
42	Diagnostic Test Software & Revision Notes	SOW Section 6.2e	R	2	As part of each Diagnostic Test Software delivery
43	Device Driver Source Code & Documentation	SOW Section 6.4f	R	2	As part of each Device Driver Source Code delivery
44	Quality Assurance Plan	SOW Section 7.1.1	A	3	Within twenty-eight (28) calendar days after contract award
45	Class I Configuration Management (CM) Changes	SOW Section 7.1.3	A	2	Within five (5) calendar days after Contractor CM review
46	Class II CM Changes	SOW Section 7.1.3	R	2	Within five (5) calendar days after Contractor CM review
47	Anomaly Reports	SOW Section 7.1.4	A	2	Within five (5) calendar days after Contractor Anomaly Review Process determines disposition

48	Parts Stress Analysis Criteria if different from EEE-INST- 002	SOW Section 7.3.1	A	2	Within twenty-eight (28) calendar days after contract award
49	Preliminary Parts Stress Analysis	SOW Section 7.3.1	R	2	Within ten (10) calendar days before PDR
50	Parts Stress Analysis (Final)	SOW Section 7.3.1	A	2	Within ten (10) calendar days before CDR
51	Worst-Case Circuit Analysis (Preliminary)	SOW Section 7.3.2	R	2	Within fifteen (15) calendar days before PDR
52	Worst-Case Circuit Analysis (Final)	SOW Section 7.3.2	A	2	Within fifteen (15) calendar days before CDR
53	Preliminary Reliability Prediction	SOW Section 7.3.3	I	2	Within fifteen (15) calendar days before PDR
54	Reliability Prediction (Final)	SOW Section 7.3.3	A	2	Within fifteen (15) calendar days before CDR
55	Preliminary Limited Life Items	SOW Section 7.3.4	I	2	Within fifteen (15) calendar days before PDR
56	Limited Life Items (Final)	SOW Section 7.3.4	A	2	Within fifteen (15) calendar days before CDR
57	Trend Parameter List	SOW Section 7.5.2	R	3	Within five (5) calendar days prior to PER
58	Test and Trend Analysis Reports	SOW Section 7.5.2	I	1	Delivered at PSR
59	Printed Wiring Board (PWB) Coupons	SOW Section 7.6.5.1	A	1 Coupon per board	Deliver within Twenty-one (21) calendar days before start of PWB assembly

60	Advanced Packaging Technology Requirements Documentation	SOW Section 7.6.5.3	A	2	Within twenty-eight (28) calendar days after contract award
61	Parts Identification List (Preliminary)	SOW Section 7.7.1	R	5	Within fifteen (15) calendar days before PDR
62	Parts Identification List (Final)	SOW Section 7.7.1	A	5	Within fifteen (15) calendar days before CDR
63	Documentation on Custom Devices	SOW Section 7.7.3	A	2	Within twenty-eight (28) calendar days after contract award
64	Plastic Encapsulated Microcircuit	SOW Section 7.7.4	A	2	Within twenty-eight (28) calendar days after contract award
65	Radiation Test Plans (If Applicable)	SOW Section 7.7.5	R	2	Plans submitted within thirty (30) calendar days prior to test. Returned with comments within fifteen (15) calendar days.
66	Radiation Test Reports	SOW Section 7.7.5	A	2	Within ten (10) calendar days after test
67	Recertification Plans for Parts >5Yrs (If Applicable)	SOW Section 7.7.7	A	2	Within fifteen (15) calendar days before CDR
68	As-Built Parts List	SOW Section 7.7.78	R	1	Due at PSR
69	Alert/Advisory Disposition and Preparation	SOW Section 7.7.9	R	2	Due within three (3) working days after Contractor disposition
70	Preliminary Material Identification & Usage List	SOW Sect 7.8.1	A	5	Within fifteen (15) calendar days before PDR

71	Materials Identification & Usage List (Final)	SOW Sect 7.8.1	A	5	Within fifteen (15) calendar days before CDR
72	As-Built Materials List	SOW Section 7.8.1	R	1	Due within Five (5) calendar days prior to PSR
73	Preliminary Materials Usage Agreement	SOW Section 7.8.1	R	2	Within fifteen (15) calendar days before PDR
74	Materials Usage Agreement (Final)	SOW Section 7.8.1	A	2	Within fifteen (15) calendar days before CDR
75	Limited-Life Items List	SOW Sect 7.8.10	A	2	Within fifteen (15) calendar days before PDR
76	Spares Recommendation	SOW Sect 9.0	I	2	Due at SRR

D.3 Technical Support Deliverables and Schedules

Item #	Description	Reference	Quantity / Unit	Delivery Date
1	Technical Support for Preliminary & Pre-Release Interface & RF Compatibility Testing Activities	SOW Section 4.4	1 Lot	Per negotiated test schedule throughout the contract Performance Period
2	Technical Support for Post-Release Interface & RF Compatibility Testing	SOW Section 4.4	1 Lot	Per negotiated test schedule throughout the contract Performance Period

3	Technical Support for Spacecraft Level, and Observatory Level Integration & Test activities	SOW Section 4.4	1 Lot	Per negotiated test schedule throughout the contract Performance Period